Viewpoint

Banisteria, Number 41, pages 101-107

Rectifying the Inequity and Bias: The Case for Investigating Non-Insect Terrestrial Invertebrates in the Southeastern United States

Rowland M. Shelley

Research Laboratory
North Carolina State Museum of Natural Sciences
MSC #1626
Raleigh, North Carolina 27699-1626
rowland.shelley@naturalsciences.org

ABSTRACT

Except for insects, terrestrial organisms are rarely addressed in invertebrate-oriented zoology courses. The focus understandably is marine, but ignoring the diverse, air-breathing invertebrates deprives students of learning opportunities that can potentially lead to jobs in environmental consulting and management, for example at the 901 areas with preserved terrestrial habitat in the southeastern United States. Environmental management agencies depend on zoologists for basic faunal information and cannot preserve what they do not know. University classes can conveniently investigate terrestrial invertebrates in conjunction with trips to marine labs, both in forests along highways leading to the coast and in ones near the labs themselves. Introducing undergraduate students to terrestrial invertebrates is necessary to eliminate the information void on these organisms.

Key words: environmental management, habitat, marine, milliped, organisms, Southeast, zoology.

INTRODUCTION

On 9 March 2013, the North Carolina State Museum of Natural Sciences (NCSM) hosted a symposium on non-insect terrestrial invertebrates in the southeastern United States (US), defined as the region east of the Mississippi and south of the Ohio and Potomac rivers (Fig. 1). It constituted the initial effort to rectify the unjustified bias against these organisms in this region, and to our knowledge it was also the first meeting on this topic ever held in North America. Presentations covered planarians, nematodes, earthworms, leeches, gastropods, isopods, diplopods, chilopods, spiders, opilionids, scorpions, acarines, and miscellaneous arachnids. The event was cited in *Banisteria* and widely publicized to university biological science departments, governmental agencies, and environmental consulting firms, although few outsiders attended. Nevertheless, the participants learned a lot about organisms that regional zoologists have been stepping on, trampling, and squashing all their lives without even noticing. I present below my introductory talk that briefly describes my zoological background and how I discovered this general field and realized how biased my training had been. These magnificent, highly evolved, and specialized organisms are generally ignored in invertebrate-oriented zoology courses in favor of marine organisms, and it is time for this inequity to end.

NARRATIVE

I cannot remember a time when I did not know that I wanted to be a zoologist. Even at age 4, when my parents enrolled me in Mrs. Sykes' Rhythm School after World War II, I knew that illuminating and enhancing knowledge of animals was my life's mission.

At the University of North Carolina-Chapel Hill (UNC) in the early 1960s, I took every zoology course I could fit in my schedule and experienced a

Fig. 1. Southeastern United States, as defined at the NCSM Non-Insect Terrestrial Invertebrate Symposium, 9 March 2013.

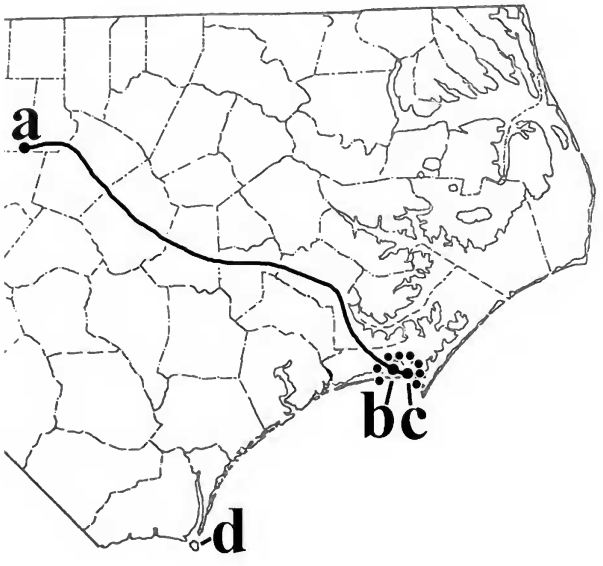

Fig. 2. Approximate course of US highway 70 from UNC-Chapel Hill (a) to the UNC Institute of Marine Sciences, Morehead City (b), and the Duke Marine lab, Beaufort (c). The area of coastal forests that can be conveniently investigated while visiting these marine labs is denoted by the arc of small dots. Bald Head Island (d) is the easternmost site for the xystodesmid milliped, *Apheloria tigana*.

breakthrough in the one on Invertebrate Zoology. The professor led the class on several field trips to the UNC and Duke marine labs, in Morehead City and Beaufort, respectively (Fig. 2), and I was shocked by the staggering diversity of marine organisms. I had no idea that life of this magnitude existed and became hooked on invertebrates, an exciting, though phylogenetically artificial, assemblage. I concluded that invertebrates are where the action is in zoology and where I was heading professionally.

In the pre-interstate highway era, driving from Chapel Hill to Morehead City/Beaufort on US 70 took three hours, and with one exception, we drove straight to the coast. On that occasion, the professor stopped at a bridge so students could dip their nets into a stream and view aquatic life, but we never stopped at a field or forest in any successional stage to view terrestrial organisms. We learned in lectures about US marine and oceanographic laboratories – particularly those at Dauphin Island, Alabama; the University of Miami; Sapelo Island, Georgia; the Baruch Lab, South Carolina; Virginia Institute of Marine Science; Woods Hole, Massachusetts; Friday Harbor, Washington; and Scripps, California – but equivalent terrestrial biological labs and field stations (Fig. 3) – such as Mountain Lake, Virginia; Highlands, North Carolina; Tall Timbers and Archbold, Florida; the Southwestern Research Station, Arizona; and the Hastings Natural History Reservation and other University of California Natural Preserves – were never mentioned. I recall "covering" both myriapods and arachnids in two lectures. Devoting substantially more time to marine organisms is understandable because life began in the sea and its biodiversity far exceeds those in freshwater and on land, but doing so to the veritable exclusion of the multitudinous non-insect, air-breathing invertebrates is not. This constitutes an overt and tacit bias that deprives students of learning opportunities and sends the erroneous message that such organisms are somehow "inferior" and/or zoologically insignificant. Undergraduate students are likely to accept without question the inherent messages in such biases, and I was not the only one in this course who did.

When I became the first Invertebrate Curator at the NCSM in 1971, I received one instruction from the Director: "Don't work with marine organisms, because there are numerous coastal marine labs, or insects, because there are too many and entomology programs exist at three regional universities – NC State, Virginia Tech, and Clemson. Work with aquatic and terrestrial invertebrates that nobody is studying." As all I knew then were the marine invertebrates that he said to avoid, I was momentarily lost, but I had always been fascinated by multilegged arthropods. I toured the

Fig. 3. US terrestrial biological field laboratories in 1966. Those mentioned in the text are (a) Mountain Lake, Virginia; (b) Highlands, North Carolina; (c, d) Tall Timbers and Archbold, Florida; (e) Southwestern Research Station, Arizona; (f) Hastings Natural History Reservation, California.

Smithsonian Institution's invertebrate holdings and Ralph Crabill, Curator of Myriapods and Arachnids, allowed me to view the milliped (diplopod) collection under the watchful eye of his technician. At that time I didn't know one diplopod from another, but I was astounded by the diversity of colors, sizes, and body forms and shocked to realize that what I thought was a minor and insignificant zoological class is actually enormously diverse. This led me to wonder, "I took the invertebrate course at a major university, why weren't students told this? Why didn't classes stop at least once to look for millipeds on all those coastal field trips?" I had found my group and, with mentoring from Richard Hoffman (Fig. 4), began sampling them in the Southeast, where I was again stunned by the diversity and numbers of non-insect invertebrates in every conceivable biotope. Never having learned otherwise, I thought only a handful of land snails existed and all spiders build webs. I also observed obviously different earthworms and isopods, pseudoscorpions on many decaying logs, and obviously different opilionids gliding over the substrate.

How could my invertebrate professor have induced the monstrously false impression that land invertebrates barely warrant mention and only marine invertebrates warrant study? I learned the answer in 1974 at a statewide conservation meeting that he also attended. During a 15 minute break, I wandered through a wooded area smaller than a football field and collected around 4-5 milliped orders and 9-10 families, which I put in a jar to show him. He eyeballed them quickly, handed the jar back, and said, "OK." How many zoological classes are there in which one can find that level of diversity in that short a time in that small an area without even trying? Not very many. I had just shown a zoology professor something he did not know, and he shrugged it off. He was so into his marine bias that he had little interest in air-breathing organisms, and while everyone is entitled to biases, he unintentionally transferred his to impressionable students.

University curriculums and courses have changed dramatically since the 1960s, but to my knowledge most invertebrate-oriented classes still conduct field trips to marine labs without spending even 15 minutes examining air-breathing organisms in terrestrial habitats along the highways they travel. What is the reason for this glaring omission? Can it be as simple as the fact that they do not live in water? In order to survive outside of water, these invertebrates had to solve formidable biological problems, for example desiccation. Organisms cannot reproduce and sustain species if they dry out, shrivel up, and die, and

Fig. 4. Richard Lawrence Hoffman (1927-2012), Grand Master of Diplopodology.

some land invertebrates actually thrive in arid deserts. Excretion is another problem for terrestrial organisms, which have to detoxify and eliminate nitrogenous waste without depleting their body fluids and again, drying, shriveling, and dying. Respiration is yet another. A gill is useless outside of water; air-breathing organisms had to evolve new respiratory structures and even systems, and they did all of these and more quite successfully. On a global scale, many land invertebrate taxa are enormously diverse, having radiated into vast arrays of environments and biotopes. Consequently, I submit that the fact that these invertebrates live outside of water makes them more interesting, not less; this is all the more reason to study them and all the more reason to introduce students to them.

Today's environmental age provides a practical reason to investigate air-breathing organisms and teach students about them; doing so can lead to employment opportunities and jobs. Environmental consulting is a relatively new profession in which faunal surveys are conducted and Environmental Impact Statements and governmental regulations are addressed. National and state parks/forests employ salaried "resource specialists," but effective management requires detailed knowledge of the organisms inhabiting the environments, and the responsibility for generating this knowledge lies with zoologists. Invertebrates are fundamental components of terrestrial ecosystems, but since most zoologists ignore them, it is difficult, if not impossible, for environmental managers to obtain needed information. In the Southeast, 901 areas with natural habitat (172 and 729 at federal and state levels, respectively), many with environmental managers and resource specialists, have been preserved, and this figure omits historic sites, battlefields, university and private forests (Appendices 1-2), and National Monuments, as with the possible exception of Russell Cave, Alabama, all southeastern National Monuments are primarily historical with little if any natural area. Though preserved primarily because of their "wet" features, National Seashores and Wild and Scenic Rivers contain terrestrial ecosystems, inhabited by air-breathing organisms, that require management just as do the marine and aquatic environments. Even minute patches of quasi-natural habitat can harbor significant terrestrial invertebrates, as exemplified by Buxton Woods and Nags Head Woods preserves, which share the North Carolina Outer Banks with Cape Hatteras National Seashore and municipalities like Nags Head, Kitty Hawk, and Kill Devil Hills (Fig. 5). Five indigenous diplopods inhabit the former and two, the latter (Shelley, 2000) (Table 1); they range westward to the central Plains, north to New England/Canada, and south to Florida/Gulf States. In the Xystodesmidae

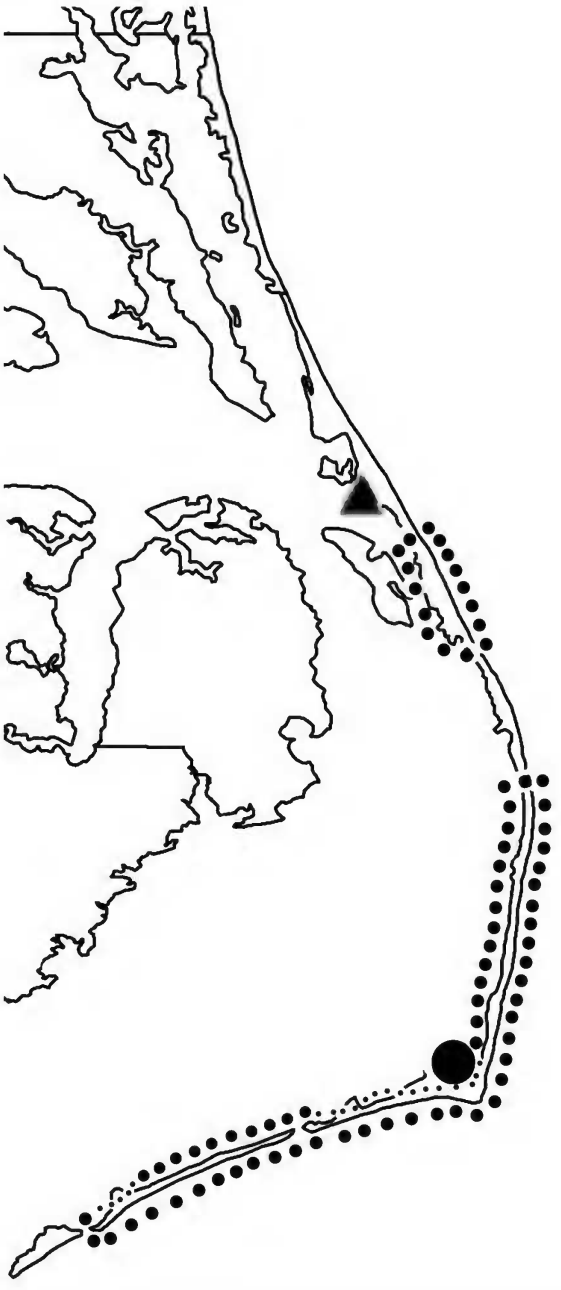

Fig. 5. Outer Banks of North Carolina showing the locations of Cape Hatteras National Seashore (dotted lines), Nags Head Woods (triangle), and Buxton Woods (large dot).

(order Polydesmida), *Apheloria tigana* Chamberlin occurs on Bald Head Island, south of Wilmington and Ft. Fisher (Figs. 2d, 6), despite vacation homes and golf courses (Shelley & McAllister, 2007), and *Sigmoria latior hoffmani* Shelley inhabits woods adjoining the strand at Edisto Beach, South Carolina (Fig. 7) (Shelley & Whitehead, 1986). Farther south, *Sigmoria australis*

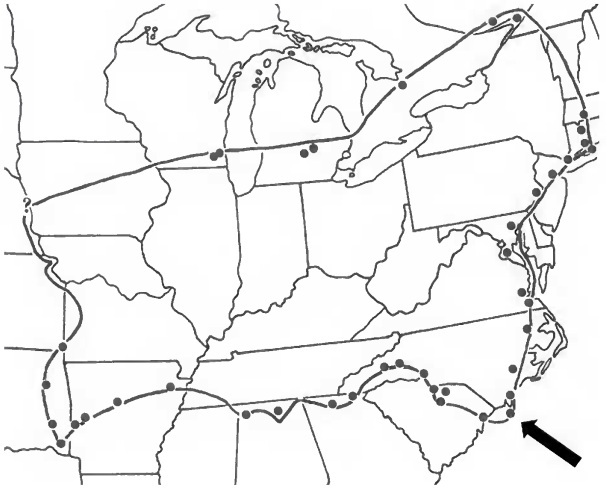

Fig. 6. Distribution of *Apheloria* showing the occurrence of *A. tigana* on Bald Head Island, North Carolina (arrow).

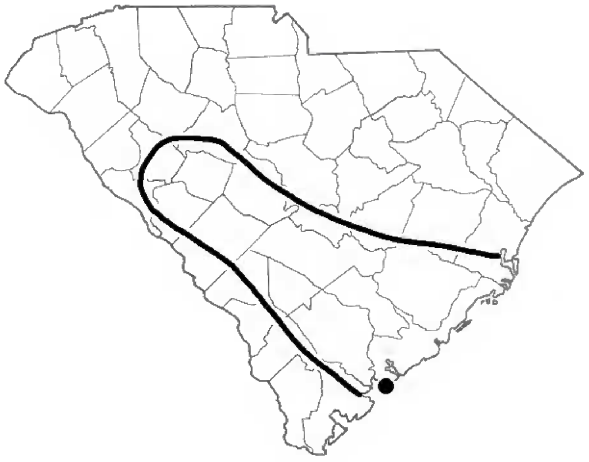

Fig. 7. Distribution of *Sigmoria latior hoffmani* showing occurrence on Edisto Beach, South Carolina (dot).

Shelley and *S. serrata* (Shelley) inhabit coastal forests of South Carolina, Georgia, and Florida, and the entire known range of the latter is the forested islands and narrow strip of land east of interstate highway 95 (Fig. 8) (Shelley, 1984; Shelley & Whitehead, 1986). Consequently, if professors choose not to investigate terrestrial environments along the highways to marine labs, they and their students can do so on the coast itself (Fig. 2), when cars are parked and marine activities are not feasible. Coastal woodlands harbor significant, native, air-breathing organisms, and anthropochores wander walkways and hide in mulch at marine labs as well as on inland campuses. Though not of systematic value, the latter demonstrate the diagnostic features of their taxa and can be readily examined under marine-lab microscopes. Terrestrial invertebrates lack swimming appendages and the feathery, frilly gills of marine organisms, but they are no less evolved and

Table 1. Distributions of indigenous millipeds on the North Carolina Outer Banks.

Species (Order: Family)	Nags Head Woods	Buxton Woods	Western range limits	Northern range limits	Southern range limits	References
Virgoiulus minutus (Brandt) (Julida: Blaniulidae)	X		se OK & e TX	s MI & NY	n peninsular FL & Gulf Coast w to LA	McAllister et al., 2005
Pseudopolydesmus serratus (Say) (Polydesmida: Polydesmidae)	X	X	Fargo, ND, central KS, eastcentral TX	Fargo, ND to Québec City, Québec	FL panhandle & Gulf Coast to s TX	Shelley & Snyder, 2012
Scytonotus granulatus (Say) (Polydesmida: Polydesmidae)		X	e NE to e OK	sw Québec to Sault Ste. Marie, Ontario	s AR, n MS, & AL, s coastal SC	Shelley, 1994; Shelley et al., 2005
Oriulus venustus (Wood) (Julida: Parajulidae)		X	Edmonton, Alberta to se Utah	Edmonton, Alberta to n NY & VT	Gulf Coast of LA	Shelley, 2002
Narceus americanus (Beauvois) (Spirobolida: Spirobolidae)		X	westcentral OK & central TX	Upper Peninsula of MI to s Québec	Big Pine Key, FL & Gulf Coast of TX	Keeton, 1960; Shelley et al., 2006
Cleidogona sp. (unidentifiable ♀) (Chordeumatida: Cleidogonidae)		X	NA	NA	NA	

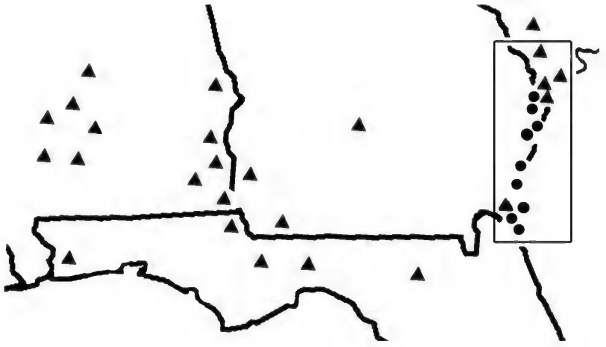

Fig. 8. Distributions of *Sigmoria australis* (triangles) and *S. serrata* (dots); the open box outlines occurrences along the coastal strips of South Carolina, Georgia, and Florida.

specialized for their microhabitats. If zoologists are to fulfill their role in today's environmental age, they and their students need to learn about the multitude of air-breathing invertebrates that have survived for hundreds of millions of years in the detritus beneath their very feet. It is time to end the overt bias against terrestrial organisms and for students to be routinely introduced to them in invertebrate-oriented zoology courses.

LITERATURE CITED

Keeton, W. T. 1960. A taxonomic study of the milliped family Spirobolidae (Diplopoda: Spirobolida). Memoirs of the American Entomological Society 17: 1-146.

McAllister, C. T., R. M. Shelley, H. Enghoff, & Z. D. Ramsey. 2005. Distribution of the milliped *Virgoiulus minutus* (Brandt, 1841): First records from Mississippi, Oklahoma, and Texas (Julida: Blaniulidae). Western North American Naturalist 65: 258-266.

Shelley, R. M. 1984. Revision of the milliped genus *Cheiropus* (Polydesmida: Xystodesmidae). Proceedings of the Biological Society of Washington 97: 263-284.

Shelley, R. M. 1994 (1993). Revision of the milliped genus *Scytonotus* Koch (Polydesmida: Polydesmidae). Brimleyana 19: 1-60.

Shelley, R. M. 2000. Annotated checklist of the millipeds of North Carolina (Arthropoda: Diplopoda), with remarks on the genus *Sigmoria* Chamberlin (Polydesmida: Xystodesmidae). Journal of the Elisha Mitchell Scientific Society 116: 177-205.

Shelley, R. M. 2002. The milliped genus *Oriulus* Chamberlin (Julida: Parajulidae). Canadian Journal of Zoology 80: 100-109.

Shelley, R. M., & C. T. McAllister. 2007. Distribution of the milliped genus *Apheloria* Chamberlin, 1921: Summaries of peripheral localities and ones of *A. virginiensis* (Drury, 1770) west of the Mississippi River (Polydesmida: Xystodesmidae). Western North American Naturalist 67: 258-269.

Shelley, R. M., C. T. McAllister, & M. F. Medrano. 2006. Distribution of the milliped genus *Narceus* Rafinesque, 1820 (Spirobolida: Spirobolidae): Occurrences in New England and west of the Mississippi River; a summary of peripheral localities; and first records from Connecticut, Delaware, Maine, and Minnesota. Western North American Naturalist 66: 374-389.

Shelley, R. M., C. T. McAllister, & Z. D. Ramsey. 2005. Discovery of the milliped *Scytonotus granulatus* (Say, 1821) in Oklahoma and Alabama, with a review of its distribution (Polydesmida: Polydesmidae). Western North American Naturalist 65: 112-117.

Shelley, R. M., & B. A. Snyder. 2012. Millipeds from the eastern Dakotas and western Minnesota, USA, with an account of *Pseudopolydesmus serratus* (Say, 1821) (Polydesmida: Polydesmidae); first published records from six states and the District of Columbia. Insecta Mundi (0239): 1-17.

Shelley, R. M., & D. R. Whitehead. 1986. A reconsideration of the milliped genus *Sigmoria*, with a revision of *Deltotaria*, and an analysis of the genera in the tribe Apheloriini (Polydesmida: Xystodesmidae). Memoirs of the American Entomological Society 35: 1-223.

Appendix 1. Federally preserved natural areas in the Southeast.

National Parks (8): Biscayne, Congaree, Dry Tortugas, Everglades, Great Smoky Mountains, Mammoth Cave, Prince William Forest, Shenandoah.

National Parkways (5): Blue Ridge, Colonial, Foothills, George Washington, Natchez Trace.

National Seashores (6): Assateague, Canaveral, Cape Hatteras, Cape Lookout, Cumberland Island, Gulf Islands.

National Recreation Areas (3): Chattahoochee River, Gauley River, Land between the Lakes.

National Preserves (2): Big Cypress, Timucuan Ecological and Historic.

National Wild and Scenic Rivers (4): Big South Fork, Bluestone, New, Obed.

National Historical and Scenic Trails (4): Appalachian, Natchez, Overmountain Victory, Trail of Tears.

National Forests (26):

Alabama (4): Bankhead, Conecuh, Talladega, Tuskegee.
Florida (3): Appalachicola, Ocala, Osceola.
Georgia (2): Chattahoochee, Oconee.
Kentucky (1): Daniel Boone.
Mississippi (6): Bienville, Delta, Desoto, Holly Springs, Homochitto, Tombigbee.
North Carolina (4): Croatan, Nantahala, Pisgah, Uwharrie.
South Carolina (2): Francis Marion, Sumter.
Tennessee (1): Cherokee.
Virginia (2): George Washington, Jefferson.
West Virginia (1): Monongahela.

National Wildlife Refuges (116):

Alabama (10), Florida (29), Georgia (11), Kentucky (1), Louisiana (6 east of the Mississippi River), Mississippi (17), North Carolina (10), South Carolina (8), Tennessee (8), Virginia (14), West Virginia (2).

Appendix 2. State-level preserved natural areas in the Southeast, numbers per state in each category.

State Parks and Natural Areas (611):

Alabama (24), Florida (157), Georgia (65), Kentucky (41), Louisiana (6 east of the Mississippi River), Mississippi (25), North Carolina (59), South Carolina (47), Tennessee (55), Virginia (95), West Virginia (37).

State Forests (118):

Alabama (6), Florida (35), Georgia (8), Kentucky (7), Louisiana (0 east of the Mississippi River), Mississippi (2), North Carolina (9), South Carolina (6), Tennessee (15), Virginia (21), West Virginia (9).